which bears, with seamen, the ugly name of "Dead Man's Bay," from an embayed vessel caught in a south-west gale seldom escaping shipwreck. More than half a century back, Fleet was inundated from a breach in the beach, and the church washed down, and many houses in Chesilton destroyed.

It is said locally, that the material is so finely graduated, that a native boatman or fisherman can tell in the darkest night the exact locality his boat may come ashore or be beached on, by picking up a handful of the gravel. In a south-west gale it is next to impossible to stand on the eastern crest, from the rain of pebbles projected over its summit by the breaking waves.

The Chesil is shown with great accuracy in early manuscript maps, especially in a remarkable series of drawings collected by the great Cecil, well known at the British Museum as "Lord Burleigh's Book;" also in drawings by Collins and Lilly. From these it would appear, that two or three centuries back the "Fleet" was wider, leading to the inference that the beach had retreated landward; but a close inspection of the bank does not support this conclusion, but appears to show that the surplus material is driven in heavy weather right over the crest sloping towards the "Fleet," the area of which has been narrowed and reduced by this continued process.

The gradation of material here again shows the ultimate leeward movement from west to east, due to preponderance of winds from the first quarter; the altitude from three to four times that of the normal elevation of ordinary English beaches above high water; also the upper plateau above the usual neap and spring "fulls" are striking features, showing its abnormal character.

The largest shingle travelling to leeward and to the summit, is illustrative of the accumulative energy of the heavier projectiles, and their being less acted on by the recoil than the smaller materials.

It may be well to notice here the soundings taken in H.M.S. *Beagle*, between Santa Cruz and the Falkland Islands, referred to by the late Mr. Darwin in his work "Geological Observations," published in 1876, and which he truly describes as presenting the usual phenomena in such cases. The material quickly and regularly decreasing in size with increased depth and distance from shore, under two miles out large and small pebbles were found intermixed.

Miles.	Depth, fathoms.	
At 2 to 4	11 to 12	Pebbles size of walnuts and smaller.
4 to 7	17 to 19	Do. size of hazel nuts.
10 to 11	23 to 25	$\frac{3}{10}''$ to $\frac{4}{10}''$ ms. diameter.
12	30 to 40	$\frac{2}{10}''$ diameter.
22 to 150	45 to 65	$\frac{1}{10}''$ do. to fine sand.

This is confirmatory of, or supported by, observations around our own coasts.

J. B. REDMAN

6, Queen Anne's Gate, Westminster, S.W., June 10

Meteor

ON Wednesday, June 7, 9.45 p.m. G.M.T., at a station 396 yards north-west by west of the transit-circle of the observatory, Mr. W. H. Robinson's attention was attracted by the sudden appearance of a fine meteor about 3° below Mars, which passed through a point 5° below Regulus, and, continuing its course about 12° further, finally disappeared. Almost instantly after being first seen, it shone very brightly, then assumed a train of detached luminous beads, and towards the end of its path burst, presenting an appearance similar to the bursting of a rocket. Its greatest brilliancy was equal to Venus. The length of the whole track was about 25°, and the time of visibility of the train was about five seconds.

E. J. STONE

Radcliffe Observatory, Oxford, June 8

Earthquakes in Naples

THE seismographs of the Vesuvian Observatory and of the Naples University have shown increased activity the last two days. This culminated this morning at 6.47 a.m. in a distinct shock seven seconds duration, direction north to south, chiefly undulatory, but elevatory towards the end. From these facts Prof. Palmieri considered it to come from a distance, and not of local origin. This was proved by telegrams from Isurnia and Vinchiaturo in the Apennines. All to-day the amount of vapour from Vesuvius is much more abundant, and this evening it is brilliant; the quantity of lava flowing is increased. This is a good example on a small scale of seismic activity having its focus in a mountain chain affecting the neighbouring volcanoes.

Naples, June 6 H. J. JOHNSTON-LAVIS

THE "POLYPHEMUS"

HER MAJESTY'S ship *Polyphemus*, which has been five years under construction, is now being prepared for her final trials. She contains so many peculiarities of design and novelties of various kinds in her machinery and fittings that much scientific interest attaches to her performances. Her form is different from that of any other ship ever built. The part above water has been described as resembling a cylinder floating on its side and deeply immersed, which is tapered at the ends to form a bow and stern. An idea of her appearance above water may be obtained by imagining such a cylinder to be flattened over a large portion of its area to form a deck, and to float at a height of 4 feet 6 inches out of water. The whole of the exposed part of this surface, which has great curvature near the water line, and enters the water at an angle of about 45 degrees, is plated over with steel armour, which is carried some distance below water. The curvature of the sides is continued to a depth of several feet below the water line, and from this point they turn sharply in and converge towards each other at the keel almost in straight lines. A cross section of the vessel is similar to a pegtop, which is floating in water at a depth below its greatest breadth, and the emersed part of which presents a convex surface only. Upon this form of hull an iron superstructure is mounted, which carries a hurricane deck from which the ship is worked, and to which the openings into the main body of the ship are carried up. Two protected coverings are fitted on this deck, one at each end, which are connected with the structure of the hull, and give means of communication with the interior. There are three revolving turrets on each side, which are each armed with one of the heaviest Nordenfelt guns. This superstructure may all be shot away without injuring the vessel or impairing her powers, except as regards the use of the Nordenfelt guns.

The lines of the ship are very fine, and have been determined chiefly with a view to great speed. The armour plating is very light; no heavy guns are carried; many devices have been adopted to reduce the weight of the machinery; and some of the main fighting qualities of most other men-of-war have been sacrificed, in order that a high speed may be realised. The speed she was designed for is 17 knots; although with the great amount of horse-power; for her size, she is intended to indicate, a higher speed might be expected if it is efficiently utilised. The offensive weapons of the *Polyphemus* consist of the ram and torpedo. She will carry no guns except six Nordenfelt machine-guns, which will each be carried in a projecting turret at the height of the flying deck. These will serve to repel boat attack; but for offensive operations against powerful vessels, she will only be able to employ the ram and torpedoes. The successful use of these weapons will depend primarily upon speed. High speed is essential, to prevent failure in ramming; and in using torpedoes under heavy gun-fire, it is very important to be able to approach an enemy quickly, and to get away again with all possible celerity, as the contingencies of this mode of fighting may require. The efficiency of the *Polyphemus* thus being a question of speed, it will be understood why so many sacrifices have been made in order to enhance this quality. The vessel has been constructed as light as possible throughout, and saving of weight has been carried to a great extent.

The hull is built of mild steel; the frames being of Bessemer, and the bottom plating of Landore-Siemens steel. There is a double bottom, and the hold of the ship is largely divided into separate watertight compart ments by means of bulkheads. A longitudinal bulkhead is fitted at the middle line; the boilers are contained in four separate water-tight compartments; the engines in two; and the coal bunkers are also water-tight.

The engines and boilers are manufactured by Messrs. Humphreys and Co. There are two pairs of engines working twin screws. They are of the horizontal compound type, the cylinders of each pair being 38 inches and 64 inches in diameter, and the stroke 39 inches. They are intended to indicate an aggregate horse power of 5500. These engines are remarkable for their lightness and the comparatively small space they occupy. Most of their novel features have been adopted for the purpose of economising weight and space. They are almost entirely of wrought iron, Whitworth steel, and gun-metal; very little cast iron being used in their construction. The screws are three-bladed, and are 14 feet in diameter, with 15 feet to 17 feet pitch. The shafts are left bare where they come outside the hull of the ship, and are not surrounded by tubes, as is usual in ships of the Navy. These tubes have been dispensed with for the purpose of diminishing the resistance. The boilers are of the locomotive type; and these also were adopted in preference to the ordinary marine boiler, for the purpose of saving weight and space. They are 5 feet 3 inches in diameter, and 14 feet 4 inches in length, and work with a steam pressure of 120 tons per square inch. The shells are of steel, the fire-boxes of iron, and tubes of brass; and they are similar to ordinary locomotive boilers, except that the tubes are shorter and the fire wells less deep. The stoke-holds are closed in, and forced draught is worked with, as in the fast torpedo boats. This is supplied by four fans, two of which are 4 feet and the other two 3 feet 6 inches in diameter. The fan engines have 9-inch cylinders, and 4½ inches stroke, and run at the rate of 900 to 1000 revolutions per minute when working at full speed.

The trials of the machinery have, so far, not been successful, chiefly on account of difficulties with the boilers. During the first series of trials, on March 2, 4, and 6 last, nothing could be done on account of priming. The greatest speed realised was 10 to 12 knots, when the boilers primed so badly that a stop had to be come to. On March 31 there was another trial, the last down to the present time, when the difficulties of priming were mainly got over. The indicated horse-power on that occasion was about 5000, and the speed a little over 17 knots. The air-pressure in the stoke-holds, which gave the forced draught, was equivalent to 5 inches of water. On this occasion the boiler-tubes leaked very badly, so that the full power could not be realised. The priming was due to oil from the engines getting into the boilers, and this now appears to be remedied. In the torpedo boats that are fitted with locomotive boilers, the same difficulty arises, and oil is not used at all in the cylinders, or only very sparingly. The leaking of the tubes is a more serious difficulty to get over, although in the *Polyphemus* the arrangements appear to admit of improvement. For instance, solid iron stays were fitted in the midst of the brass tubes; and it must be obvious that the unequal rate of expansion of the stays and tubes when heated to a high temperature must have considerably strained the tube plates. These stays are now being removed, and new tubes are being fitted throughout, the ends of which are to be screwed into the tube plates.

This difficulty of leaky tubes is not peculiar to the *Polyphemus*. Messrs. Thornycroft are in the same position with a large number of torpedo boats they have completed for the British Government, and which are undergoing a similar ordeal of testing by the Admiralty engineers. These boilers cannot be got to stand satisfactorily, and a number of experiments have just been carried out at Portsmouth upon tubes fitted in various ways in a torpedo boat boiler, which, it is hoped, will show how the present defects can be remedied. Locomotive boilers are not adapted for working continuously at a high rate, and for steaming at full speed over long distances. The strain put upon the boiler, and the work attempted to be got out of it, is too great under these circumstances. What is being done in the *Polyphemus* and in the torpedo boats, is to get the advantage of the lightness of this type of boilers; and only to press them up to their full power for comparatively short times when required in an emergency.

The armour plating is of steel; and here again we find an attempt to combine great defensive power with extreme lightness. It extends over the whole of the above water-portion of the hull, and for a short distance below the water-line. There are first two half-inch thicknesses of Landore-Siemens steel, upon which are placed plates of Whitworth fluid-compressed steel, one inch thick. Outside of this is another layer of hard Whitworth steel, one inch thick, which is tested to a strain of sixty-eight tons per square inch. This outer layer is fitted in small plates or scales ten inches square, secured with coned steel screw bolts, one at the centre of each of the plates, and one at each of the corners. Along the middle of the turtle-back deck these scales are omitted, and the armour is there only 2 inches thick. The bases of the trunks from the hatchways to the flying deck are protected by a glacis of 6-inch steel armour to a height of 3 feet 6 inches above the deck; and the front of the foremost trunk is plated to a height of about 5 feet above the flying deck, with 8 inches of steel-faced armour, which gives protection to the pilot tower.

The armament, as has been stated, merely consists of six Nordenfelt machine-guns, which are each mounted in a revolving turret that projects from the side of the flying deck. The fighting weapons she possesses are the ram and torpedoes. The former is very long and strongly constructed. It is, however, interfered with by a tube for ejecting torpedoes right ahead, which is fixed in the centre of the ram. This seems a doubtful expedient to adopt, and to endanger to some extent both the ram and the torpedo-tube. The bow has been made so as to protect this tube as much as possible. The torpedo armament consists of the tube referred to for ejecting torpedoes right ahead, and of two tubes on each side, also placed under water, in a compartment at the fore side of the boiler-rooms. In this torpedo compartment one tube on each side is fixed right abeam, and the other in the direction of about 20 degrees at the fore side of the beam. There is only means of firing one torpedo end on, the other four tubes being on the broadside. It is questionable as to the merits of this arrangement, considering that the end-on position will be the one for attacking from in the *Polyphemus*, for the purpose of using the ram, and also to enable the greatest possible resistance to be got out of her thin armour. Independent air-compressing machinery for the torpedoes is carried in each of the torpedo-chambers, in which also a number of torpedoes will be carried ready for use.

The height of the hull proper above the water line is, as we have said, 4 feet 6 inches. It is kept low to reduce the chances of penetration; but to furnish more buoyancy than this small freeboard gives, a strange device has been adopted. At the keel of the ship a deep rectangular recess is made in which about 300 tons of iron ballast is carried. This ballast is so fixed that it can be let go at pleasure, and the ship lightened accordingly. The draught and trim may thus be regulated to some extent should the ship be injured in action. If the whole of the ballast is let go it will lighten her about 14 inches.

As manœuvring power is of great importance to such a vessel as the *Polyphemus*, an attempt is made to increase it by means of bow rudders. Two of the rudders, of the balanced form, are placed forward, one on each side of the bow torpedo tube. They can be drawn up into apertures inside the hull when not required for use; and when working they may be coupled up with the engine working the stern rudder, and all three rudders worked together. The dead wood has been cut away aft to a large extent in order to reduce the resistance to turning.

DOUBLE STARS

SOME stars when looked at in a telescope are seen really to consist of two stars so near together that the naked eye is not able to distinguish them, but sees them as a single star.[1] The knowledge of some of these objects may be presumed to be almost as old as the telescope. In fact Hevel remarked some of them in the middle of the seventeenth century, but no attention was paid to them, as it was thought that they were really far asunder in space, and merely appeared close together in the heavens, because they were nearly in the same visual ray. It thus escaped notice that one star frequently moves round the other, and Lambert, as late as 1761, founded his opinion that those fixed stars that appear near others, were in no physical connection with them, upon this absence of relative motion, because, as he says in his "Cosmologische Briefe," if they do not move round each other, and still gravitate towards each other, they must long ago have collapsed. But a few years after the Rev. John Michell applied the rules of the calculation of probabilities to the stars in the Pleiades, and showed that it was exceedingly improbable that these stars could appear so near together, if their proximity was the result of a random scattering of the stars over the heavens, and he showed that among 40,000 stars, one could expect to find only one pair within twelve seconds of arc of each other, and none nearer. These speculations were, however wholly conjectural, as long as no proper observations were available, and it was therefore to the purpose when the highly merited Jesuit, Christian Mayer, of the observatory at Mannheim, founded by the Elector of Pfalz, commenced to search for, and systematically to observe, double stars. But he met with no support from his contemporaries, and had to defend his opinions in several polemical pamphlets. His instrument, a mural quadrant by Bird, was scarcely sufficient for the purpose, and his opinion, that, "satellites" of the brighter fixed stars were found at a distance of as much as three degrees, was certainly wrong in the instances he adduced, though Mädler has shown that stars as far asunder may possibly be physically connected.[2] We must, therefore, consider William Herschel to be the first who proved the existence of double stars. This he did by aid of micrometric measures,[3] which he originally had made with the view of finding the parallax of fixed stars, similar observations having previously been attempted by the Rev. Roger Long, of Pembroke College, Cambridge, who, however, had not been very successful.

Herschel commenced micrometric measures in 1776, when he observed θ Orionis. In 1779 he began systematically to search for and measure double stars, and as early as 1782 he laid his first "Catalogue of Double Stars" before the Royal Society. It contained 269 objects, but few of which had been observed by Chr. Mayer. Subsequently he published other catalogues, which, however, contain many stars more than 32″ asunder, which are not now considered as double stars proper; but of the latter Herschel discovered between four and five hundred. He measured double stars micrometrically up to 1785, and again for some years after 1790. The measures showed some discrepancies, but it was impossible to decide whether the relative motion of the components—for changed their position some of them evidently had—was rectilinear or otherwise, and whether it in some cases perhaps arose from the proper motion of one star. However, already in 1794 Herschel explained how they must move in curved paths on account of their mutual gravitation, and in 1803 appeared that famous "account of the changes that have happened during the last twenty-five years in the relative situation of double stars," in which he, from actual measures, proved this to be a fact. But Continental astronomers were nevertheless slow to give in to so novel and startling a revelation. In France even Lalande openly expressed his want of faith in these disclosures, notwithstanding his high regard for Herschel's merits in other respects.—At the end of his active career Herschel had the pleasure to see his son John Herschel take up this subject with fervour. South, the friend of this illustrious astronomer, joined him in this work, and obtained thus a place in the scientific world, to which his own merits, only for this connection would scarcely have entitled him. J. Herschel went in 1834 to the Cape of Good Hope, where he discovered and made some measures of above two thousand double stars on the southern sky with his 20-feet reflecting telescope. He continued to take an active interest in these stars till his death in 1871, when he left behind unfinished manuscripts that showed that he had been engaged on a general catalogue of double stars and the observations made of them. It contained about 10,000 entries.

FIG I.

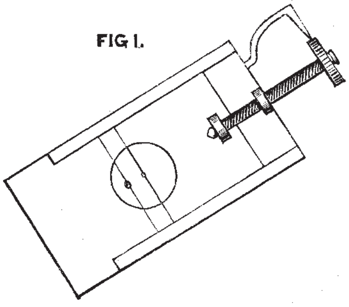
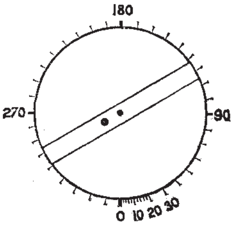


FIG 2.



Meantime Struve in Russia had commenced a series of double-star measures, which is even now unsurpassed, as well with regard to extent as to consistency. In 1824 he received a 10-inch refractor, mounted equatorially, from Fraunhofer of Munich, and with this magnificent instru-

---

[1] Mizar and Alcor, the "test-star," in the great bear, present to the naked eye very much the same appearance as a double star does, when seen in a telescope. Their distance is about a lunar radius. It is sometimes said that distances less than five minutes are not visible to the eye, but when wearing glasses I see ϵ Lyræ, the distance of whose components is less than four minutes, double.

[2] It was evidently Chr. Mayer's opinion that the smaller star shone in reflected light. The term "double star" had been applied by previous observers, who little dreamt that these stars would become so interesting.

[3] It may be as well to explain in a few words the instrument with which such minute quantities are measured. It is called a micrometer, and forms the eyepiece of a large telescope. It is well known that in the focus of the object-glass of a telescope, the image of the object contemplated appears inverted. Now in this focus are stretched two parallel spider lines, at least one of which is moveable by an extremely fine screw. The magnitude of the object or the distance between the two components of the double star are thus measured in revolutions or fractions of a revolution of this screw; for which purpose the head of the screw is divided into hundredths, the tenths of which are estimated by the eye (see Fig. 1). The value in seconds of arc of each revolution of the screw is either ascertained by measuring some known distance or by measuring the length of a revolution in parts of an inch (a very small quantity) and dividing this by the focal length of the object-glass expressed in inches. The value of a revolution is generally found to vary a little with the temperature, as the steel of which the screw is made expands or contracts with the heat, but this is counteracted by changes in the focal length of the object-glass. It is of more importance to examine the irregularities of the screw, the different turns of which might not exactly be of the same size. Even parts of each turn might be slightly different. However modern engineers have carried the making of screws on the lathe to so high a perfection, that there are screws made in which no errors can with certainty be ascertained. It also deserves to be remarked that it is more easy to make a screw accurate the finer it is.—But the screw gives us only the distance of one star from the other. We require to know also in what direction it is situated. For this purpose the plate on which the micrometric screw and the wires are fixed can be revolved, and the wires placed parallel to the line joining the centres of the two stars. The angle is read off on a circle in firm connection with the tube. This, the so-called angle of position is counted from the line connecting the principal star with the pole. From north 0° round through east 90°, south 180°, and west 270° (see Fig. 2). This circle is adjusted by allowing the stars in their daily motion to run from east to west along the wires. The index should then point to 90° or 270°. But it must be kept in view that the images are inverted, so that *e.g.* when looking southwards, north appears down.